EXHIBIT A

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United States Patent [19]

Jones et al.

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[54] **METHOD AND APPARATUS FOR DISCRIMINATING AND COUNTING DOCUMENTS**

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[*] Notice: This patent is subject to a terminal disclaimer.

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Related U.S. Application Data

[63] Continuation-in-part of application No. 08/573,392, Dec. 15, 1995, Pat. No. 5,790,697, which is a continuation-in-part of application No. 08/399,854, Mar. 7, 1995, Pat. No. 5,875,259, application No. 08/394,752, Feb. 27, 1995, Pat. No. 5,724,438, application No. 08/362,848, Dec. 22, 1994, Pat. No. 5,870,487, application No. 08/340,031, Nov. 14, 1994, Pat. No. 5,815,592, application No. 08/317,349, Oct. 4, 1994, Pat. No. 5,640,463, application No. 08/287,882, Aug. 9, 1994, Pat. No. 5,652,802, application No. 08/243,807, May 16, 1994, Pat. No. 5,633,949, and application No. 08/226,660, Apr. 12, 1994, said application No. 08/399,854, is a continuation-in-part of application No. 08/394,752, application No. 08/340,031, and application No. 08/287,882, said application No. 08/394,752, is a continuation-in-part of application No. 08/340,031, and application No. 08/127,334, Sep. 27, 1993, Pat. No. 5,467,405, said application No. 08/362,848, is a continuation-in-part of application No. 08/340,031, which is a continuation-in-part of application No. 08/243,807, and application No. 08/207,592, Mar. 8, 1994, Pat. No. 5,467,406, said application No. 08/287,882, is a continuation-in-part of application No. 08/207,592, application No. 08/127,334, and application No. 08/219,093, Mar. 29, 1994, abandoned, said application No. 08/243,807, is a continuation-in-part of application No. 08/219,093, and application No. 08/127,334, said application No. 08/226,660, is a continuation-in-part of application No. 08/127,334, said application No. 08/219,093, is a continuation-in-part of application No. 08/127,334, said application No. 08/207,592, is a continuation-in-part of application No. 08/127,334, which is a continuation of application No. 07/885,648, May 19, 1992, Pat. No. 5,295,196, which is a continuation-in-part of application No. 07/475,111, Feb. 5, 1990, abandoned

[60] Provisional application No. 60/018,563, May 29, 1996, provisional application No. 60/034,954, Jan. 16, 1997, and provisional application No. 60/038,340, Feb. 27, 1997.

[51] **Int. Cl.^{6}** **G06K 9/00**

[52] **U.S. Cl.** **382/135**; 382/318; 382/320; 382/321

[58] **Field of Search** 382/135, 218, 382/318, 319, 320, 321, 322, 323; 194/206; 250/556; 356/71; 209/534

[56] **References Cited**

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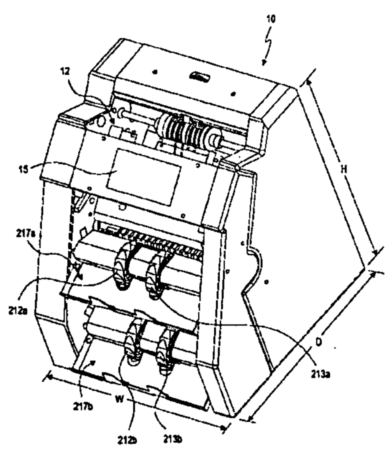
Primary Examiner—Phuoc Tran

[57] **ABSTRACT**

A currency evaluating device for receiving a stack of currency bills, rapidly discriminating the bills in the stack and then re-stacking the bills which comprises an input receptacle, a transport mechanism for transporting in the direction of the narrow dimension of the bills from the input receptacle to one of a plurality of output receptacles, at a rate in excess of about 800 bills per minute, and a discriminating unit for determining the denomination of each bill. The device may also include an authenticating unit for determining the genuineness of the bills. The authenticating unit may detect by use of a plurality of magnetoresistive sensors or may detect by ultraviolet light. Alternatively, a currency counting and evaluation device comprises an input receptacle, a transport mechanism for transporting the bills in the direction of the narrow dimension to one of a plurality of output receptacles at a rate in excess of about 800 bills per minute, a stationary optical scanning head, means for sampling, a memory for storing characteristic signal samples and a signal processor.

52 Claims, 22 Drawing Sheets



5,465,301 incorporated herein by reference. For example, a security thread may appear in one color at ambient temperatures under transmitted light and may appear in a second color or appear colorless at or above an activation temperature or vice versa. Alternatively, bills may be printed and/or coated with such thermochromatic materials. Such bills may or may not include security threads and any included security threads may or may not also be printed or coated with thermochromatic materials. To detect for the proper characteristics of bills containing such thermochromatic materials and/or containing threads employing such thermochromatic materials, the above described embodiments may be altered to scan a bill at different temperatures. For example, a bill could first be scanned at ambient temperatures, and then be transported downstream where the temperature of the bill is raised to or above an activation temperature and scanned again at the higher temperature. For example, FIG. **4** could be modified to employ two sets of pairs of sensors **334***a–c*, one set downstream of the other with the downstream sensors be located in a region where the temperature is evaluated relative to the temperature of the region where the first set of sensors are located. A bill adjacent to the first and second sets of sensors **334***a–c* may be illuminated either with visible light or ultraviolet light (if the thermochromatic material contains materials whose fluorescent characteristics alter with changes in temperature). Accordingly, the presence of the appropriate color or absence of color may be detected for the different temperatures and the detected information may be used to authenticate and/or denominate the bill.

In addition to magnetic and optical sensing, other techniques of detecting characteristic information of currency include electrical conductivity sensing, capacitive sensing (U.S. Pat. No. 5,122,754 [watermark, security thread]; 3,764,899 [thickness]; 3,815,021 [dielectric properties]; 5,151,607 [security thread]), and mechanical sensing (U.S. Pat. No. 4,381,447 [limpness]; 4,255,651 [thickness]).

Turning to the discrimination of the denomination of bills, in the case of U.S. currency, for instance, it has been determined that the central, approximately two-inch (approximately 5 cm) portion of currency bills, as scanned across the central section of the narrow dimension of the bill, provides sufficient data for distinguishing among the various U.S. currency denominations. According to one embodiment, an optical encoder (see e.g. FIGS. **1***a–c*) can be used to control the scanning process so that reflectance samples are taken for a set period of time and only after a certain period of time has elapsed after the borderline **17***a* is detected, thereby restricting the scanning to the desired central portion of the narrow dimension of the bill.

FIGS. **5–7** illustrate the scanning process in more detail. Referring to FIG. **6**, as a bill **17** is advanced in a direction parallel to the narrow edges of the bill, scanning via a slit in the scanhead **18***a* or **18***b* is effected along a segment S of the central portion of the bill **17**. This segment S begins a fixed distance D inboard of the borderline **17***a*. As the bill **17** traverses the scanhead, a strip s of the segment S is always illuminated, and the photodetector **26** produces a continuous output signal which is proportional to the intensity of the light reflected from the illuminated strip s at any given instant. This output is sampled at intervals controlled by the encoder, so that the sampling intervals are precisely synchronized with the movement of the bill across the scanhead.

As illustrated in FIGS. **5** and **7**, the sampling intervals in one embodiment are selected so that the strips s that are illuminated for successive samples overlap one another. The odd-numbered and even-numbered sample strips have been separated in FIGS. **5** and **7** to more clearly illustrate this overlap. For example, the first and second strips s1 and s2 overlap each other, the second and third strips s2 and s3 overlap each other, and so on. Each adjacent pair of strips overlap each other. In the illustrative example, this is accomplished by sampling strips that are 0.050 inch (0.127 cm) wide at 0.029 inch (0.074 cm) intervals, along a segment S that is 1.83 inch (4.65 cm) long (64 samples).

FIGS. **8***a* and **8***b* illustrate two opposing surfaces of U.S. bills. The printed pattern on the black and green surfaces of the bill are each enclosed by respective thin borderlines B_1 and B_2. As a bill is advanced in a direction parallel to the narrow edges of the bill, scanning via the wide slit of one of the scanheads is effected along a segment S_A of the central portion of the black surface of the bill (FIG. **8***a*). As previously stated, the orientation of the bill along the transport path determines whether the upper or lower scanhead scans the black surface of the bill. This segment S_A begins a fixed distance D_1 inboard of the borderline B_1, which is located a distance W_1 from the edge of the bill. The scanning along segment S_A is as describe in connection with FIGS. **5–7**.

Similarly, the other of the two scanheads scans a segment S_B of the central portion of the green surface of the bill (FIG. **8***b*). The orientation of the bill along the transport path determines whether the upper or lower scanhead scans the green surface of the bill. This segment S_B begins a fixed distance D_2 inboard of the border line B_2, which is located a distance W_2 from the edge of the bill. For U.S. currency, the distance W_2 on the green surface is greater than the distance W_1 on the black surface. It is this feature of U.S. currency which permits one to determine the orientation of the bill relative to the upper and lower scanheads **18**, thereby permitting one to select only the data samples corresponding to the green surface for correlation to the master characteristic patterns. The scanning along segment S_B is as describe in connection with FIGS. **5–7**.

The optical sensing and correlation technique is based upon using the above process to generate a series of stored intensity signal patterns using genuine bills for each denomination of currency that is to be detected. According to one embodiment, two or four sets of master intensity signal samples are generated and stored within the system memory, preferably in the form of an EPROM **34** (see FIG. **1***a*), for each detectable currency denomination. According to one embodiment these are sets of master green-surface intensity signal samples. In the case of U.S. currency, the sets of master intensity signal samples for each bill are generated from optical scans, performed on the green surface of the bill and taken along both the "forward" and "reverse" directions relative to the pattern printed on the bill. Alternatively, the optical scanning may be performed on the black side of U.S. currency bills or on either surface of foreign bills. Additionally, the optical scanning may be performed on both sides of a bill.

In adapting this technique to U.S. currency, for example, sets of stored intensity signal samples are generated and stored for seven different denominations of U.S. currency, i.e., $1, $2, $5, $10, $20, $50 and $100. For bills which produce significant pattern changes when shifted slightly to the left or right, such as the $2, the $10 and/or the $100 bills in U. S. currency, two green-side patterns for each of the "forward" and "reverse" directions may be stored, each pair of patterns for the same direction represent two scan areas that are slightly displaced from each other along the long dimension of the bill. Accordingly, a set of number of different green-side master characteristic patterns are stored